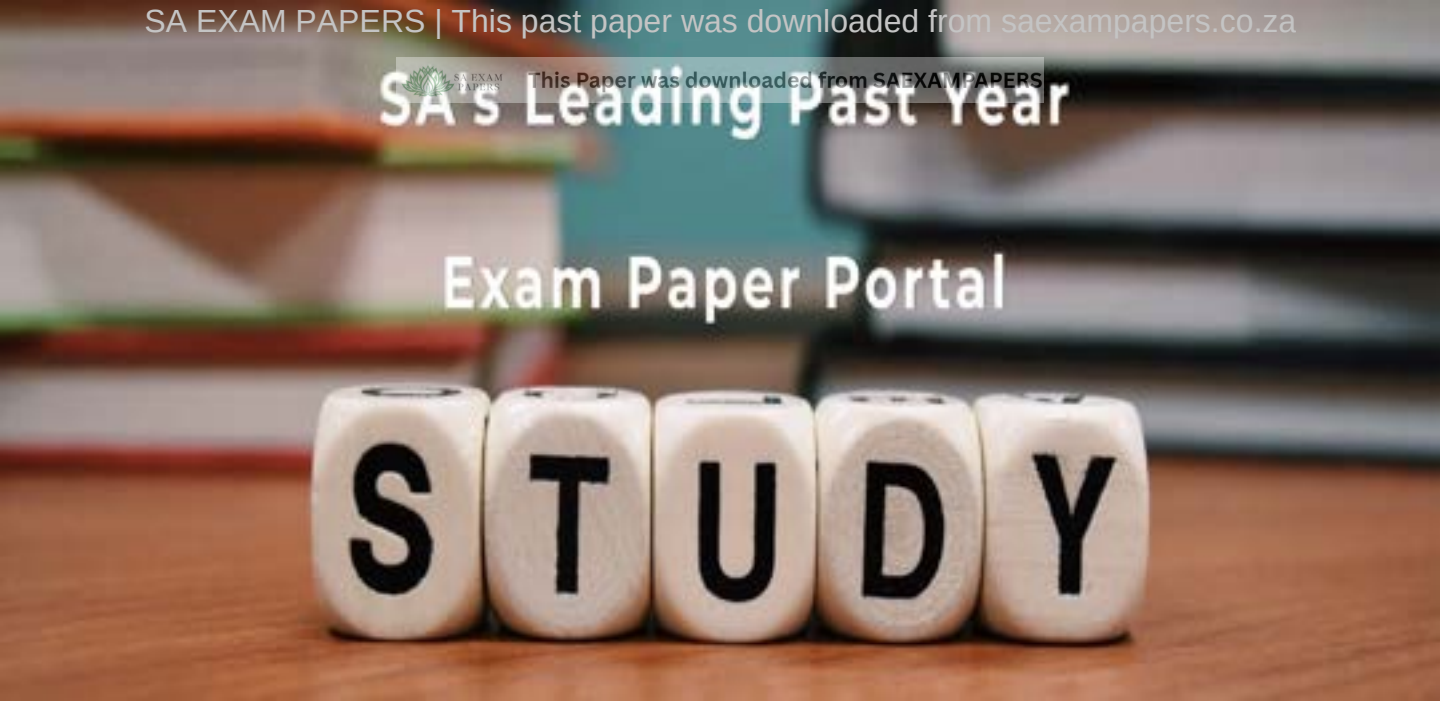


GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

JUNE EXAMINATION
GRADE 12

2026

MARKING GUIDELINES

ELECTRICAL TECHNOLOGY: POWER SYSTEMS

14 pages

INSTRUCTIONS TO THE MARKERS

1. All questions with multiple answers imply that any relevant, acceptable answer should be considered.

2. Calculations:

   2.1 All calculations must show the formulas.

   2.2 Substitution of values must be done correctly.

   2.3 All answers MUST contain the correct unit to be considered.

   2.4 Alternative methods must be considered, provided that the correct answer is obtained.

   2.5 Where an incorrect answer could be carried over to the next step, the first answer will be deemed incorrect. However, should the incorrect answer be carried over correctly, the marker has to recalculate the values, using the incorrect answer from the first calculation. If correctly used, the candidate should receive the full marks for subsequent calculations.

   2.6 Markers should consider that candidates' answers may deviate slightly from the marking guideline, depending on how and where in the calculation rounding-off was used.

3. These marking guidelines are only a guide with model answers.

4. Alternative interpretations must be considered and marked on merit.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

1.1	C ✓	(1)
1.2	C ✓	(1)
1.3	B ✓	(1)
1.4	C ✓	(1)
1.5	C ✓	(1)
1.6	D ✓	(1)
1.7	A ✓	(1)
1.8	B ✓	(1)
1.9	C ✓	(1)
1.10	C ✓	(1)
1.11	B ✓	(1)
1.12	A ✓	(1)
1.13	A ✓	(1)
1.14	B ✓	(1)
1.15	A ✓	(1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 Where all layers of skin have been burned, causing skin damage, ✓ affecting fat, ✓muscle and even bone damage.
[ANY TWO] (2)

2.2
- An employer shall not dismiss an employee without the correct procedures being followed. ✓
- An employer shall not reduce the remuneration of an employee as punishment. ✓
- Alter terms of condition of employment to one that is less favourable.
- Alter a position relative to other employees employed by that employer to disadvantage them.

[ANY TWO] (2)

2.3 It is an unexpected or an extraordinary event ✓ that does not require emergency procedures. ✓ (2)

2.4 Manufacturers who design and manufacture an article for use at work must ensure that the article is safe when used properly ✓ and the information and procedure for using the article being manufactured is clear and must ensure that it is safe to use. ✓ (2)

2.5 Actions that will have serious consequences when they occur, ✓but there is a low chance of these risks happening.✓ (2)

[10]

QUESTION 3: RLC CIRCUITS

3.1 I_C leads V_C ✓by 90°.✓ (out of phase) (2)

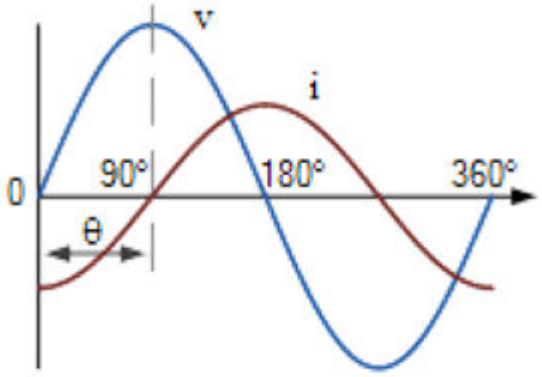
3.2
- The value of the series resistor✓
- The LC ratio✓ (2)

3.3 3.3.1 A phasor diagram is a graphical representation of a sinusoidal alternating current or voltage ✓ in an RLC circuit. ✓ (2)

3.3.2 The resonant frequency is the frequency at which the inductive reactance ✓ is equal to the capacitive reactance. ✓

NOTE : *All characteristics of resonance explained correctly will be accepted.* (2)

3.4



- Full cycles drawn correctly ✓
- Phase difference correct ✓
- Waveforms labelled correctly ✓ (3)

3.5 3.5.1 $X_C = \frac{1}{2\pi fc}$ ✓

$X_C = \frac{1}{2\pi(60)(200 \times 10^{-6})}$ ✓

$X_C = 13{,}26\ \Omega$ ✓ (3)

3.5.2 $I = \frac{V}{Z}$ ✓

$I = \frac{110}{101{,}65}$ ✓

$I = 1{,}08\ A$ ✓ (3)

3.5.3 $Z = \sqrt{R^2 + (X_L - X_C)^2}$ ✓

$R = \sqrt{Z^2 - (X_L - X_C)^2}$

$R = \sqrt{(101{,}65)^2 - (31{,}55 - 13{,}26)^2}$ ✓

$R = 99{,}99\ \Omega$ ✓ (3)

3.5.4 $X_L = 2\pi fL$ ✓

$L = \frac{X_L}{2\pi f}$

$L = \frac{31{,}55}{2\pi(60)}$ ✓

$L = 0{,}084\ H$ ✓ (3)

3.6 3.6.1 $I_T = \sqrt{{I_R}^2 + (I_C - I_L)^2}$ ✓

$I_T = \sqrt{(0{,}9)^2 + (0{,}7 - 0{,}6)^2}$ ✓

$I_T = 0{,}91\ A$ ✓ (3)

3.6.2 $V = IR$ ✓

$V = (0{,}91)(120)$ ✓

$V = 109{,}2\ V$ ✓ (3)

3.6.3 $Z = \frac{V}{I_T}$ ✓

$Z = \frac{109,2}{0,91}$ ✓

$Z = 120\ \Omega$ ✓ (3)

3.6.4 $cos\theta = \frac{I_R}{I_T}$ ✓

$\theta = (cos^{-1})\frac{I_R}{I_T}$

$\theta = (cos^{-1})\frac{0,9}{0,91}$ ✓

$\theta = 8,5°$ ✓

Leading ✓ (4)

3.7 Selectivity is a measure of how well a resonant circuit responds to a range of frequencies ✓ and separates other frequencies. ✓ (2)

3.8 3.8.1 A decrease in resistance increases the Q factor. ✓ (1)

3.8.2 $Q = \frac{X_L}{R}$ ✓

$Q = \frac{1\ 500}{50}$ ✓

$Q = 30$ ✓ (3)

3.8.3 $f_r = \frac{f_1 + f_2}{2}$ ✓

$f_r = \frac{1\ 000 + 2\ 000}{2}$ ✓

$f_r = 1\ 500\ H_Z$ ✓ (3)

[45]

QUESTION 4: THREE-PHASE AC GENERATION

4.1
- A three-phase system is more economical. ✓
- A three-phase system can be connected in star or delta. ✓
- A three-phase system can supply three-phase and single-phase installations.
- Phase balancing can be done in a three-phase system.

[ANY TWO] (2)

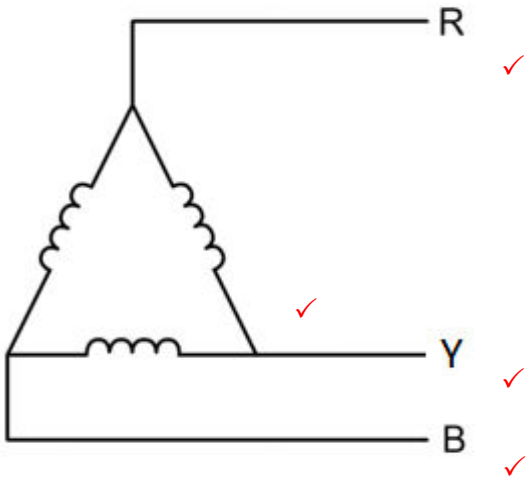
4.2
- Reduced current in supply conductors. ✓
- Smaller supply conductors required. ✓
- Reduced cost of smaller supply conductors.
- Equipment will last longer.

[ANY TWO] (2)

4.3 Static capacitors ✓
Synchronous motors
Phase advancers
[ANY ONE] (1)

4.4 The voltage measured between any two ✓ of the lines ✓ is known as the line voltage or line-to-line voltage. (2)

4. 5



If L1; L2 or L3 is used it is deemed correct (4)

4.6 4.6.1 22 KV ✓
50 Hz ✓ (2)

4.6.2 It is a device that measures the amount of electric energy consumed ✓by a residence, a business, or an electrically powered device over a certain time period.✓ (2)

4.7 $\eta = \frac{P_{OUT}}{P_{IN}} \times 100$ ✓

$\eta = \frac{3800}{4000} \times 100$ ✓ (3)

$\eta = 95\ \%$ ✓

4.8 The secondary windings of the transformer are connected in star ✓to create a neutral point ✓enabling the transformer to power both single- and three-phase loads. (2)

4.9 The transformer is a step-up transformer that increases the voltage ✓across the lines and in turn reduces the current through it. ✓This reduces the copper losses. (2)

4.10 4.10.1 $V_L = \sqrt{3}\, V_{PH}$ ✓

$V_L = \sqrt{3}\, x\ 230$ ✓

$V_L = 398.37\ V$ ✓ (3)

4.10.2 $P = \sqrt{3}\, V_L I_L cos\theta$ ✓

$P = \sqrt{3}\, x\ 398.37x\ 35 \cos 18\ °$ ✓

$P = 22967.91\ W$

$P = 22.97\ KW$ ✓ (3)

4.11 4.11.1 $S = \sqrt{3}\, V_L I_L$

$I_L = \frac{S}{\sqrt{3}\, V_L}$ ✓

$I_L = \frac{200\ 000}{\sqrt{3}\ 400}$ ✓

$I_L = 288{,}68\ A$ ✓ (3)

4.11.2 $I_L = \sqrt{3}\, I_{PH}$

$I_{PH} = \frac{I_L}{\sqrt{3}}$ ✓

$I_{PH} = \frac{288{,}68}{\sqrt{3}}$ ✓

$I_{PH} = 166{,}67\ A$ ✓ (3)

4.11.3 $Cos\ \theta = \frac{P}{S}$ ✓

$Cos\ \theta = \frac{180\ 000}{200\ 000}$ ✓

$Cos\ \theta = 0{,}9$ ✓ (3)

4.11.4 $Q = \sqrt{3}\ V_L I_L sin\theta$ ✓

$Q = \sqrt{3}\ x\ 400\ x\ 288.68\ x \sin(Cos^{-1}0{,}9)$ ✓

$Q = 87\ 173{,}38\ VAr$ ✓ (3)

[40]

QUESTION 5: THREE PHASE TRANSFORMERS

5.1
- Core type ✓
- Shell type ✓ (2)

5.2
- Constant overloading ✓
- Insufficient ventilation ✓
- Transformer oil may be impure due to carbonization
- Transformer oil may be insufficient

[ANY TWO] (2)

5.3 5.3.1
- Transformer ratio ✓
- Voltage rating ✓
- Current rating ✓
- Power rating
- Efficiency
- Size
- Frequency

[ANY THREE] (3)

5.3.2 Star ✓ (1)

5.4 5.4.1 Dry type transformers ✓ (Natural cooling)
Oil-immersed transformers ✓ (Forced cooling) (2)

5.4.2 Buchholtz relay ✓ (1)

5.5 By means of mutual inductance between two magnetically connected coils, ✓ it transfers electrical energy from one electrical current to another without changing the frequency. ✓ (2)

5.6

- To increase or decrease voltage. ✓
- Used in industrial installations and in low voltage domestic distribution systems. ✓
- Three-phase as well as single-phase transformers are used in commercial centres, retail centres and light industries. ✓
- Some households require single- and three-phase power, which is provided by lamppost transformers.
- Three-phase transformers are used exclusively in three-phase transmission and distribution networks.
- Large factories receive three-phase power and must step it down to the required voltage themselves.

[ANY THREE] (3)

5.7 5.7.1

$$\frac{N_1}{N_2} = \frac{V_{PH1}}{V_{PH2}} \checkmark$$

$$V_{PH2} = \frac{N_2 \times V_{PH1}}{N_1}$$

$$V_{PH2} = \frac{1 \times 6000}{25} \checkmark$$

$$V_{PH2} = 240\ V \checkmark$$ (3)

5.7.2

$$V_{L2} = \sqrt{3}\ V_{PH2} \checkmark$$

$$V_{L2} = \sqrt{3}(240) \checkmark$$

$$V_{L2} = 415{,}69\ V \checkmark$$ (3)

5.7.3

$$Cos\ \theta = \frac{P}{S} \checkmark$$

$$S = \frac{P}{Cos\ \theta}$$

$$S = \frac{50\ 000}{0{,}9} \checkmark$$

$$S = 55\ 555{,}56\ VA \checkmark$$

$$S = 55{,}56\ kVA$$ (3)

5.7.4 $S_{(primary)} = S_{(secondary)}$ ✓

$I_{L1} = \frac{S}{\sqrt{3}\,V_{L1}}$ ✓

$I_{L1} = \frac{55\,555{,}56}{\sqrt{3}\,(6000)}$ ✓

$I_{L1} = 5{,}35\ A$ ✓

OR

$P = \sqrt{3}\,V_{L1}I_{L1}Cos\,\theta$

$I_{L1} = \frac{P}{\sqrt{3}\,V_{L1}Cos\,\theta}$

$I_{L1} = \frac{50000}{\sqrt{3}\,(6000)(0{,}9)}$

$I_{L1} = 5{,}53\ A$ (4)

5.8 5.8.1 $V_{PH} = \frac{V_L}{\sqrt{3}}$ ✓

$V_{PH} = \frac{380}{\sqrt{3}}$ ✓

$V_{PH} = 219{,}39\ V$ ✓ (3)

5.8.2 $\frac{N_1}{N_2} = \frac{V_{PH(1)}}{V_{PH(2)}}$ ✓

$N_1 = N_2 \times \frac{V_{PH(1)}}{V_{PH(2)}}$

$N_1 = 80 \times \frac{6000}{219{,}39}$ ✓

$N_1 = 2188\ turns$ ✓ (3)

5.8.3 $TR = \frac{N_1}{N_2}$ ✓

$TR = \frac{2188}{80}$ ✓

$TR = 27{,}35:1$ ✓

$TR = 27:1$

OR

$TR = \frac{V_{PH(1)}}{V_{PH(2)}}$

$TR = \frac{6000}{219{,}39}$

$TR = 27{,}35:1$

$TR = 27:1$ (3)

5.9 Dry-type transformers are equipped with tubular radiator around which air circulates, ✓ cooling the windings, ✓ therefore controlling insulation failure (2)

[40]

QUESTION 6: THREE-PHASE MOTORS AND STARTERS

6.1
- Rotor ✓
- Cooling Fan ✓
- Shaft
- Bearings

[ANY TWO] (2)

6.2
- Insulation resistance test ✓
- Continuity test ✓
- Check for loose connections.
- Bearing test

[Any two relevant answers] (2)

6.3 To reduce the voltage at start-up. ✓ This in turn reduces the starting current. ✓ Reduced starting current leads to fewer nuisance tripping problems at start or to less heat build-up and decreases the chance of burn-out of the motor. ✓ (3)

6.4 6.4.1 Because induction motors have no brushes ✓ on slip rings that cause sparks. ✓ (2)

6.4.2 120º ✓ (1)

6.4.3 When a three-phase supply is connected to the stator, each coil pair is connected to a different phase of the three-phase supply. ✓ This causes current to flow in each coil at an angle of 120º. ✓ The coils are also spaced 120º apart around the stator and the current flowing through them will magnetise each coil at a different interval ✓ one after the other at a frequency of 50 Hz creating a rotating magnetic field in the process. ✓ (4)

6.5 6.5.1
- Continuity test ✓
- Insulation resistance between windings and earth ✓ (2)

6.5.2 No. ✓ There is no continuity between V1 and V2 ✓ and V2 of the coil is short circuited to earth. ✓ (3)

6.6 To protect electrical equipment from damage ✓ during faulty operating conditions and protecting the operator of the equipment. ✓ (2)

6.7 The motor will keep on operating, but to maintain the same output power ✓ the current on the other two phases will increase. ✓ If the protection is set correctly, it will engage, protecting the motor from permanent damage. ✓ (CONSIDER RELEVANT MOTIVATED ANSWERS) (3)

6.8 6.8.1 Yes, it is suitable. ✓ (1)

6.8.2 $P = \sqrt{3}V_L I_L cos\theta$ ✓

$P = \sqrt{3}(380)(24)(0,8)$ ✓

$P = 12\,637,04\ W$ ✓ (3)

6.8.3 $\eta = \frac{P_{OUT}}{P_{IN}}\ X\ 100$ ✓

$\eta = \frac{10\ 000}{12\ 637,04}\ X\ 100$ ✓

$\eta = 79,13\ \%$ ✓ (3)

6.8.4 $\%slip = \frac{n_s - n_r}{n_s}$

$n_s = \frac{n_r}{1-slip}$ ✓

$n_s = \frac{3\ 000}{1-0,04}$ ✓

$n_s = 3\ 125\ rpm$ ✓ (3)

6.9 6.9.1 $P = \sqrt{3}V_L I_L cos\theta$

$V_L = \frac{P}{\sqrt{3}I_L cos\theta}$ ✓

$V_L = \frac{9\ 000}{\sqrt{3}(16)(0,85)}$ ✓

$V_L = 382,07\ V$ ✓ (3)

6.9.2 $P_{output} = \sqrt{3}V_L I_L cos\theta\ \eta$ ✓

$P_{output} = \sqrt{3}(382,07)(16)(0,85)(\frac{90}{100})$ ✓

$P_{output} = 8\ 100\ W$ ✓ (3)

6.9.3 $Q = \sqrt{3}V_L I_L sin\theta$ ✓

$Q = \sqrt{3}(382,07)(16)sin31,79$ ✓

$Q = 5\ 577,96\ VA_r$ ✓ (3)

6.10 6.10.1
- MC_2N/C ✓
- MC_1N/C ✓ (2)

6.10.2 A normally closed contact will allow current to flow in the circuit, ✓ MC_1will de-energize to isolate the motor from the supply ✓ when a faulty current activates the overload relay. ✓ (3)

6.10.3 While MC_1it is energized its MC_1N/Contact in series ✓ with $MC_2$is open, ✓ therefore isolating MC_2which will not energize even when START 2 is pressed. (2)

[50]

TOTAL: 200